Amendments to the Drawings:

The attached sheets of drawings include changes to Figs. 2, 9 and 10. These sheets, which includes Figs. 2 and 5-12, replace the original sheets. Various minor inadvertent errors, specifically missing or misplaced reference numbers, in FIGs. 2, 9 and 10 of the drawings, as filed, have been corrected.

Attachment: Replacement Sheet
Annotated Sheet Showing Changes

REMARKS

In view of both the amendments presented above and the following discussion, the Applicants submit that none of the claims now pending in the application is either anticipated under the provisions of 35 USC § 102 or obvious under the provisions of 35 USC § 103. Furthermore, the Applicants also submit that all of these claims now satisfy the requirements of 35 USC § 112. Thus, the Applicants believe that all of these claims are now in allowable form.

If, however, the Examiner believes that there are any unresolved issues requiring adverse final action in any of the claims now pending in the application, the Examiner should telephone Mr. Peter L. Michaelson, Esq. at (732) 542-7800 so that appropriate arrangements can be made for resolving such issues as expeditiously as possible.

Specification and abstract amendments

Various amendments have been made to the specification, as filed, to correct minor inadvertent grammatical, punctuation, spelling and formal errors; and to insert missing section headings.

A substitute specification is submitted herewith which incorporates the above amendments. The substitute specification introduces no new matter into the application. Moreover, in accordance with the provisions of M.P.E.P. Section 608.01(q), the Applicants have also enclosed a "marked-up" copy of the specification. The substitute

specification contains the same changes that are shown in the marked-up copy of the specification.

The Applicants have also replaced their abstract, as filed, with a new version to eliminate reference numerals and to correct other minor errors.

Drawings

The Applicants have discovered various minor inadvertent errors, specifically missing or misplaced reference numbers, in FIGs. 2, 9 and 10 of their drawings, as filed.

To correct these errors and expedite prosecution, the Applicants have enclosed both red-lined drawings which depict their proposed changes in red, and substitute formal drawing sheets which incorporate all these changes. The Applicants now respectfully request the Examiner's approval of these changes.

Status of claims

To simplify amending the claims and hence expedite their examination, the Applicants, rather than re-writing their claims with, in some cases, extensive amendments, have simply canceled all their prior pending claims 1-23 and substituted new claims 24-43 there for.

The new claims have been drafted to: provide enhanced clarity over the prior claims including defining the invention with increased precision, remedy all the

deficiencies noted by the Examiner, and conform to the dictates of proper US claim practice.

The following table shows the correspondence between the prior claims and those now pending.

Present Claim	Prior Claim	Present Claim	Prior Claim	Present Claim	Prior Claim
24	1	32	8	40	16
25	--	33	9	41	17
26	2	34	10	42	18
27	3	35	11	--	19
28	4	36	12	--	20
29	5	37	13	--	21
30	6	38	14	--	22
31	7	39	15	43	23

Objections

The Examiner has objected to prior claims 1-23 due to various informalities. Inasmuch as all these claims have now been canceled, this objection is moot. Nevertheless, all the informalities raised by the Examiner do not exist in new claims 24-43.

In addition, the Examiner has objected to claims 20 and 22-23 as being in improper dependent form inasmuch as each such claim failed to further limit the subject matter of a prior claim. Since claims 20-22 have not been replaced by any corresponding new claim, and claim 43, which corresponds to prior claim 23, is independent, this particular objection is also moot.

Thus, these objections should be withdrawn.

Rejections

A. Rejection under 35 USC § 112

The Examiner has rejected prior claims 8 and 20-22 under the provisions of the second paragraph of 35 USC § 112 as being indefinite. Inasmuch as all these claims have now been canceled, this rejection is moot. Inasmuch as claim 8 has been replaced by new claim 32, but claims 20-22 have no corresponding new claims, the Applicant will simply address the portion of this rejection applicable to claim 8, though discussed in the context of new claim 32. The remainder of this rejection concerning claims 20-22 is simply moot.

Specifically, the Examiner stated that claim 8 recited insufficient antecedent basis for two of its limitations, specifically "the feed" in line 3 and "the base plane" in line 6. With respect to claim 32, the limitation "the feed" finds sufficient antecedent basis in the term "a feed" recited in dependent claim 30, from which claim 32 indirectly depends. The limitation "the base plane" does not appear in claim 32 -- nor did it appear in claim 8 either. Nevertheless, this limitation does appear in new dependent claims 33, 39 and 40, all of which depend from claim 27 which provides sufficient antecedent basis through its recitation of "a base plane".

Hence, this rejection should be withdrawn.

B. Rejection under 35 USC § 102

The Examiner has rejected claims 1-8, 11-17 and 19-23 under the provisions of 35 USC § 102(b) as being anticipated by the teachings of the '792 Bellus et al patent (United States patent 5,786,792 issued to P. A. Bellus et al on July 28, 1998). Inasmuch as all these claims have now been canceled -- as noted above, this rejection is also moot. New claims 24-32 (with the exception of new claim 25) and 35-41 correspond to prior claims 1-8 and 11-17, respectively, and new claim 43 corresponds to prior claim 23. No new claims exist which correspond to prior claims 19-22. No prior claim corresponds to new dependent claim 25. Hence, to expedite prosecution, the Applicants will address this rejection in the context of these new claims and principally with respect to their new independent claims 24 and 43. In that context, this rejection is respectfully traversed.

Specifically, the Examiner believed that all the limitations of prior independent claims 1 and 19 were identically disclosed in the '792 Bellus et al patent. As the Examiner will soon appreciate, this view is incorrect with respect to new independent claims 24 and 43.

The '792 Bellus et al patent discloses a tapered notch antenna array which has a multitude of planar notched antennas, each mounted on a different vertical side wall of a monolithic three-dimensional thermoplastic grid.

As discussed in, e.g., col. 1, line 56 et seq and col. 3, line 15 et seq -- the latter with respect to FIG. 1

of this patent, antenna array 10 is fabricated on a dielectric substrate formed as three-dimensional grid 12 and illustratively from injection molded thermoplastic. Grid 12 has vertical sidewalls 14 that define a plurality of polygonal cells 16, each of which has rectilinear side walls. A notched radiator antenna, formed through appropriately plated copper, is formed on opposite surfaces of each of the sidewalls between upper edges 18 and lower edges 20 of the grid. In particular, appropriately patterned plated copper circuitry 21 which defines notched radiator 15 itself, specifically shown in FIG. 3, appears on one surface of sidewall 14 with its feed line 23, also formed of appropriately patterned plated copper, appearing on the surface of the sidewall lying directly opposite the surface containing the radiator. As shown, radiator 15 is formed of a notch that vertically extends upward from the lower to the upper edge and flares horizontally outward between the former and the latter edge.

This patent, in col. 4, line 15 et seq, discloses several methods for fabricating the array. All the methods begin, as expressly stated in col. 4, lines 18-20, by first injection molding thermoplastic material to form the grid, i.e., as stated:

> "Initially, the grid 12 is formed by injection molding of the thermoplastic material, and then cutting the grid to the proper height dimension H as shown in FIG. 1."

Once the grid is so formed, then the entire grid is plated with copper to a desired thickness which is then selectively

photoresistively-patterned and etched to form the radiator and feed patterns.

A second embodiment taught by this patent, as shown in FIG. 8 -- to which the Examiner specifically references in page 7 of the present action, differs slightly from that depicted in FIG. 1 by the addition of thin dielectric film 52 in the former. Antenna radiator 56, which defines a notch, is formed on one side of the film, with J-shaped feed element 54 formed on the immediately opposite side thereof. This film is then bent into a square box (with apparently open upper and lower ends) and inserted into a cavity, of the mold, used to form each corresponding cell in the grid that is to contain an antenna. Molten thermoplastic resin is then injected into the mold to fill all the spaces between the cells, hence forming grid-like support structure 12 (also referred hereinbelow as simply "grid 12"). In that regard, col. 4, line 66 through col. 9, line 18 expressly states, in pertinent part:

> "Referring to FIGs. 8, 8A and 8B an antenna panel structure with a stripline circuitry according to a second embodiment of the invention is referred to as reference numeral 50 which includes a grid 12 similar to FIG. 2, which has sidewalls 14 forming rectangular cells 11 and upper and lower edges 18 and 20, respectively. A thin dielectric element 52 ... forms the circuit substrate. A flexible copper circuit is formed on both sides of the film 52. On one surface of the film 52 is a feed circuit 54 in the form of a J and on the opposite side is circuit 56 which defines the antenna notch. *The film 52 is bent into a square box and inserted into the cavities of a mold that is used to mold the structural array. ... Resin 58 is injected into the mold to fill*

> *each cavity and capture the feed circuit at the walls of the respective cavities.*"
> [emphasis added]

Thus, as the Examiner can appreciate from inspecting FIG. 8, box-shaped film substrate 52 for any given cell 16, and on which the antenna elements for that cell are formed and hence supported, is a self-contained unitary structure completely enclosed within that cell formed in the grid. The film associated with that cell is not mechanically connected to the box-shaped film substrate for any of its adjacent cells, inasmuch as sidewalls 14 of grid 12 provide adequate mechanical support for all the box-shaped film substrates then situated within the grid.

The Applicants have recognized that fabricating a separate grid-like support structure on which the antennas are fabricated -- whether directly on its sidewalls (as shown by FIG. 1 in the '792 Bellus et al patent) or particular through use of a film dielectric intermediary on which those antennas are formed (as shown in FIG. 8 of that patent) -- disadvantageously adds both complexity to the manufacturing process and expense.

To provide a much simpler antenna array structure than that taught by the Bellus '792 patent, the present Applicants teach, as described in page 2, line 12 et seq and page 3, line 21 et seq -- the latter with respect to FIGs. 1 and 2 in the present application, a simplified approach based on a replicating pattern of mutually mechanically interconnected antenna supports. In particular, antenna elements are fabricated on flexible first and second sheet-shaped supports, e.g., from respective planar

blanks 2, which are then folded along fold-lines 3-6 in each blank into, e.g., a rectilinear shape. By virtue of folding, the blank forms vertical support planes 10, 11, 12 and 13 (here being sides). Prior to folding, antenna structure 100 is formed on each of the sides, with a polarization direction coplanar with a plane of that support. By folding the blanks to form the sides in an orthogonal pattern, an antenna array is then formed with successive antenna elements in adjacent folded sections being capable of receiving or emitting electro-magnetic radiation polarized in different directions. Rather than the blanks being folded into squares as shown in FIG. 1, they can be folded into step-shaped assemblies, such as 200 shown in FIG. 6. Once the blanks are so folded to construct adjacent folded step-shaped antenna assemblies, then, as shown in FIG. 4 and discussed in page 9, line 31 et seq, these adjacent assemblies 200, 201 are then mechanically connected directly to each other at or near their respective fold-lines. This connection can be accomplished through use of illustratively an appropriate clamp, e.g., clamp 202, or a glue dot. The result is an antenna array having orthogonally-oriented antenna elements 1' and 1", hence a dual-polarized array.

Once the Applicants' antenna assemblies, particularly the supports, are themselves mechanically interconnected into, e.g., a matrix arrangement, these supports, so interconnected, provide their own structural support and rigidity. Consequently, the inventive arrangement advantageously eliminates the need, in direct contrast to the teachings of the '792 Bellus et al patent, to use a separate supporting grid. By eliminating the grid

or any other such intermediate supporting structure, the present invention is far simpler and significantly less expensive to manufacture over the array taught by the '792 Bellus et al patent.

There are simply **no** teachings whatsoever, whether explicit or even implicit, in the '792 Bellus et al patent directed at how to form its antenna array without use of grid 12. In fact, since each embodiment taught by that patent relies on first forming grid 12 (see previously referenced text at col. 4, lines 18-20), any methodology that relies on eliminating the grid would lie directly opposite to the express teachings of this patent. Because the grid provides essential mechanical support to the disclosed antenna array, then no one of skill, when faced with those teachings, would be motivated to contemplate removing that grid, let alone how to do so while still yielding an operative antenna array.

It has remained for the present Applicants and only the Applicants to teach such a simplified antenna structure.

New independent claim 24 contains suitable recitations directed to the distinguishing aspects of the present invention. In particular, this claim recites as follows, with those recitations shown in a bolded typeface:

"An antenna array comprising:
first and second separate sheet-shaped supports, wherein each of the first and second sheet-shaped supports is folded along corresponding first and second fold-lines in said first and second sheet-shaped

supports, respectively, so as to form through each of said first and second sheet-shaped supports:

a first support plane, in each one of the first and second sheet-shaped supports and respectively along said first and second ones of the fold-lines, having a first antenna structure arranged for receiving or emitting electro-magnetic radiation; and

a second support plane, in each one of the first and second sheet-shaped supports and adjacent to said first support plane therein and respectively along said first and second ones of the fold-lines, the second support plane in said each one of the first and second sheet-shaped supports being positioned at an angle with respect to the first support plane also in said each one of the first and second sheet-shaped supports, respectively, and having a second antenna structure arranged for receiving or emitting electro-magnetic radiation which differs in at least one property from the electromagnetic radiation which is received or emitted by the first antenna structure; and

wherein the first and second sheet-shaped supports are physically connected to each other at or near the first and second fold-lines." [emphasis added]

New independent method claim 43 contains highly similar, though parallel limitations to those recited in claim 24.

Accordingly, the Applicants submit that neither claim 24 nor claim 43 is disclosed, let alone identically, by the teachings of the '792 Bellus et al patent. Thus, the Applicants submit that each of these claims is patentable under the provisions of 35 USC § 102 over the teachings in this patent.

Each of claims 25-32 and 35-41 depends from independent claim 24 and recites additional features over those set forth in this independent claim. Consequently, the Applicants submit that each of these dependent claims is

also patentable under the provisions of 35 USC § 102 over the teachings in the '792 Bellus et al patent for the same reasons set forth above with respect to claim 24.

This rejection should also now be withdrawn.

C. Rejections under 35 USC § 103

1. Claim 9

The Examiner has rejected dependent claim 9 under the provisions of 35 USC § 103 as being rendered obvious by the teachings of the '792 Bellus et al patent taken in view of those in the '563 Cox et al patent (United States patent 7,057,563 issued to G. A. Cox et al on June 6, 2006). Since claim 9 has now been canceled, this rejection too is now moot. Nevertheless, since claim 9 has now been replaced by new claim 41, then to expedite prosecution, the Applicant will principally address this rejection in the context of new corresponding independent claim 24 from which claim 41 depends. In that context, this rejection is respectfully traversed.

The Examiner states that all limitations recited in prior claims 1, 3, 4 and 6 are disclosed by the '792 Bellus patent. However, the Examiner concedes that that patent does not shown the additional feature, recited in prior claim 9, of "a first conducting layer extending at least partially over at least a part of the base plate". As such, the Examiner turns to the '563 Cox et al patent for that teaching. Given that missing teaching, the Examiner concludes that it would have been obvious for one skilled in

the art to modify the teachings of the '792 Bellus et al patent to include a first conductive layer as taught by the '563 Cox et al patent and thus arrive at the present invention. This conclusion is incorrect with respect to new independent claim 24 and hence claim 41 which depends there from.

The '563 Cox et al patent does disclose, particularly in col. 2, line 50 et seq and with reference to accompanying FIG. 1, the concept of extending a conductive layer 30 from vertically extending antenna radiator 20, through a 90 degree bend, over a portion of a base plane 40 to permit the radiator to be installed in a planar multilayer active array panel antenna assembly.

Nevertheless, even if such a modification, as posited by the Examiner, to the teachings of the '792 Bellus et al patent were to be made by one of skill in the art, the resulting arrangement would still include grid 12 disclosed by that patent. With reference to FIG. 2 and particularly FIG. 5 of this patent, interconnections 23 and 31 which are shown and respectively described as feedlines and metallic lines (see, e.g., col. 4, lines 13-15), would simply be replaced by a single bent conductor that accomplishes both functions, thus eliminating solder connection 33. Doing so would have **no** bearing on eliminating grid 12 as copper circuitry 21 that forms each antenna radiator 15 would still be plated directly onto sidewall 18 of each corresponding cell in the grid. The same type of single bent conductor would arise in the embodiment shown in FIG. 8 of the '792 Bellus et al patent, though the difference there being that

the single bent conductor would extend from a side wall of box-shaped film substrate 52 to base sheet 28.

There are simply **no** teachings whatsoever, whether explicit or implicit, or even any suggestions or motivations, in the combined teachings directed at how to form an antenna array, as taught by the '792 Bellus et al patent, but without use of grid 12. The same deficiencies, described above, which exist in the teachings of the '792 Bellus et al patent would still remain in the apparatus which would likely result from combining those teachings with, as the Examiner proposes, those in the '563 Cox et al patent. Advantageously, the present invention overcomes those deficiencies.

As indicated above, independent claim 24 contains suitable recitations directed to the distinguishing aspects of the present invention. The Applicants submit that this claim is not rendered obvious by the teachings in the '792 Bellus et al and '563 Cox et al patents. Hence, this claim is patentable under the provisions of 35 USC § 103.

Inasmuch as claim 41 directly depends from claim 24 and recites further distinguishing characteristics of the present invention over those recited in claim 24, the Applicants submit that this dependent claim is also not rendered obvious by the teachings in these two applied patents for the same reason set forth above with respect to claim 24. Hence, claim 41 is also patentable under the provisions of 35 USC § 103.

This rejection too should also now be withdrawn.

2. Claims 10 and 18

Lastly, the Examiner has rejected dependent claims 10 and 18 under the provisions of 35 USC § 103 as being rendered obvious by the teachings of the '792 Bellus et al patent taken in view of those in the '932 Matsui et al patent (United States patent 6,518,932 issued to T. Matsui et al on February 11, 2003). Since claims 10 and 18 have now both been canceled, this rejection is also moot. Nevertheless, since claims 10 and 18 have now been replaced by new corresponding claims 34 and 42, then to expedite prosecution, the Applicant will principally address this rejection in the context of new corresponding independent claim 24 from which both of these claims either indirectly or directly depends. In that context, this rejection is respectfully traversed.

The Examiner begins by again stating that all limitations recited in prior claim 6 are disclosed by the '792 Bellus patent. The Examiner concedes that that patent does not shown the additional features, here, as recited in prior claim 10, of "an amplifier element positioned at the second side, which amplifier element is electrically connected with a signal input to the feed" and, in prior claim 18, of "at least one of the antenna structures being connectable to further signal processing devices outside of the antenna device via a non-contact connection, such as capacitive or an inductive connection." Accordingly, the Examiner turns to the '932 Matsui et al patent for these missing teachings. With those teachings, the Examiner concludes that it would have been obvious for one skilled in the art to modify the teachings of the '792 Bellus et al

patent to include an amplifier element and an external signal processing device as taught by the '932 Matsui et al patent and thus arrive at the present invention. This conclusion is incorrect with respect to new independent claim 24, and hence claims 34 and 42 which both depend there from.

The '932 Matsui et al patent does indeed disclose, in FIG. 1A and its discussion in col. 8, line 28 et seq, integration within a microwave antenna assembly of an amplifier element, here being amplifier 109 contained within monolithic microwave integrated circuit (MMIC) 104, and use of external signal processing unit 108. However, as with the feature of using a bent single conductive element taught by the '563 Cox et al patent, neither the features of inclusion of an amplifier nor use of an external processing circuit here would have any bearing on eliminating grid 12 taught by the '792 Bellus et al patent. Neither of these two latter features has anything to do with supporting the antenna radiators themselves. Hence, any antenna structure that results from combining the teachings of the '792 Bellus et al and '932 Matsui et al patents would still contain grid 12.

As discussed above, there are simply **no** teachings whatsoever, whether explicit or implicit, or even any suggestions or motivations, in the combined teachings directed at how to form an antenna array, as taught by the '792 Bellus et al patent, but without use of grid 12. Also, as discussed, the same deficiencies which exist in the teachings of the '792 Bellus et al patent would still remain in the apparatus which would likely result from combining

those teachings with, as the Examiner proposes, those in the '932 Matsui et al patent -- deficiencies which the present invention advantageously overcomes.

Independent claim 24, as previously indicated above, contains suitable recitations directed to the distinguishing aspects of the present invention. The Applicants submit that this claim is not rendered obvious by the teachings in the '792 Bellus et al and '932 Matsui et al patents. Hence, this claim is patentable under the provisions of 35 USC § 103.

Each of claims 34 and 42 depends, either directly or indirectly, from claim 24 and recites further distinguishing characteristics of the present invention over those recited in claim 24. Hence, the Applicants submit that both of these dependent claims are also not rendered obvious by the teachings in these two applied patents for the same reason set forth above with respect to claim 24. Hence, claims 34 and 42 are also patentable under the provisions of 35 USC § 103.

Consequently, this rejection should also be withdrawn.

Conclusion

Thus, the Applicants submit that none of their claims, presently in the application, is either anticipated under the provisions of 35 USC § 102 or obvious under the provisions of 35 USC § 103. Furthermore, the Applicants

also submit that all of their claims now fully satisfy the requirements of 35 USC § 112.

Consequently, the Applicants believe that all these claims are presently in condition for allowance. Accordingly, both reconsideration of this application and its swift passage to issue are earnestly solicited.

Respectfully submitted,

January 4, 2008

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DUAL ~~POLARISED~~ POLARIZED ANTENNA DEVICE FOR AN ANTENNA ARRAY AND METHOD OF MANUFACTURING THE SAME

[0001] BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to an antenna device. The invention further relates to an antenna array, an intermediate product for an antenna device and a method for manufacturing an antenna device.

[0004] 2. Description of the Prior Art

[0005] Antenna devices are generally known and used for receiving and emitting electro-magnetic radiation and may, for example, be employed in radar and other direction finding systems, astronomical observatories and satellite receiving equipment, for example. Often, an antenna device has to receive or emit electro-magnetic radiation with differing spatial properties, for example electro-magnetic radiation with different directions of ~~polarisation~~ polarization or electro-magnetic radiation stemming from different sources (and, accordingly, emitted from different positions).

[0006] For instance, for receiving electro-magnetic radiation with different ~~polarisations~~ polarizations dual ~~polarised~~ polarized antenna ~~device~~ devices are known. A dual ~~polarised phased array~~ polarized phased-array antenna is known, for example, from the European patent publication 0 349 069 A1. This prior art document describes a ~~phased array~~ phased-array antenna having a plurality of antenna elements positioned in a matrix-shaped arrangement. The matrix comprises an assembly of two orthogonal sets of parallel insulating planar supports. Each of the insulating planar supports is provided with a conductive surface layer

patterned to form a succession of tapered notch antenna elements. The tapered notch antenna elements are distributed along an outward facing edge of the planar support. Each of the tapered notch antenna elements has a ~~polarisation~~ polarization parallel to the planar supports. The ~~phased-array~~ phased-array antenna thus comprises two orthogonal sets of line-shaped arrangements of tapered notch antenna elements, of which sets each has a respective, orthogonal ~~polarisation~~polarization.

[0007] In the ~~phased-array~~ phased-array antenna described in the above mentioned patent publication, the insulating planar supports of each set intersect and engage on the supports of the other set. To that end, the supports are provided with a slot extending from the edge of a planar support to half way across the support. The sets are positioned such that the supports of one set extend in the slots of supports of the other sets. The supports of one set thus intersect and engage with the supports of the other set to form a matrix-shaped support structure.

[0008] However, a draw-back of the antenna device described in said patent publication is that each planar support has to be provided with a multitude of slots, in which thereafter the supports of the other sets have to be positioned. Accordingly, manufacturing of the dual ~~polarised phased-array~~ polarized phased-array antenna is complex. Furthermore, the planar supports have to be made of a rigid material in order to obtain a support construction with sufficiently high stiffness, which limits the choice of materials which can be used in the antenna device.

[0009] SUMMARY OF THE INVENTION

[0010] It is an object of the invention to provide an antenna device which can receive or emit electro-magnetic radiation with different spatial properties and which can be manufactured in a ~~less complex~~ relatively simple manner. ~~Therefore, according to the invention an antenna device is provided according to claim 1.~~

[0011] Such an antenna device can be manufactured by folding a suitable intermediate product, e.g., a blank. Compared to cutting slots into rigid supports

and positioning sets of slotted rigid supports in a matrix arrangement, folding is a simple operation with few steps. The antenna device can receive or emit electro-magnetic radiation with different spatial properties because the first support plane has a first antenna structure and the second support plane is positioned at an angle with respect to the first support plane and has a second antenna structure.

[0012] Furthermore, ~~the~~ at least one sheet-shaped support is folded along at least one fold-line, which has the additional advantage that the mechanical stiffness of the antenna device is increased. A wider variety of material can thus be used for the supports, since less rigid, even flexible, materials can be used, such as, for instance, a foldable plastic sheet material, such as kapton.

[0013] Furthermore, ~~an antenna array according to claim 19 is provided. Such~~ through the present invention, an antenna array can be manufactured in a simple manner~~, by suitable folding of~~ by suitably folding one or more intermediate products.

[0014] ~~An~~ Such an intermediate product ~~according to claim 22~~ is also ~~provided~~taught. An antenna device can be manufactured in a simple operation from such intermediate ~~product~~ products by suitable folding of the support along one or more fold-lines.

[0015] A method ~~according to claim 23 is provided~~ of manufacturing such an antenna or antenna array is also taught as well. In such a method, an antenna device or antenna array is manufactured in a simple manner.

[0016] BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Specific embodiments of the invention are set forth in the dependent claims. Further details, aspects and embodiments of the invention will be described, by way of example only, with reference to the figures in the attached drawings.

[0018] FIG. 1 schematically shows a perspective view of an example of an embodiment of an antenna device according to the invention.

[0019] FIG. 2 schematically shows a top view of an example of an embodiment of a semi-finished product suitable for manufacturing an antenna device according to the invention.

[0020] FIG. 3 schematically shows a perspective, partially exploded view of a part of the semi-finished product of FIG. 2.

[0021] FIG. 4 schematically shows a perspective view of an example of an embodiment of an antenna array according to the invention.

[0022] ~~FIG.~~ FIGs. 5-8 schematically show examples of folded sheets shaped supports suitable for in an example of an embodiment of an antenna array according to the invention.

[0023] ~~FIG.~~ FIGs. 9-12 schematically show some examples of sheet shaped intermediate product suitable for manufacturing an example of an embodiment of an antenna device according to the invention.

[0024] FIG. 13 schematically shows a block diagram of an example of an embodiment of a ~~phased-array~~ phased-array antenna.

[0025] DETAILED DESCRIPTION

[0026] FIG. 1 shows an example of an embodiment of an antenna device 1. The antenna device 1 comprises a sheet-shaped support 2 which is folded along one or more, in this example four, fold-lines 3-6. Support planes 10-13 are present between the fold-lines 3-6, which support planes are obtained by means of the folding.

[0027] Each of the support planes 10-13 is provided with an antenna structure 100. In this example, each of the antenna structures 100 ~~each have~~ has an electro-magnetic ~~polarisation~~ polarization direction which is coplanar with the plane of the support plane on which the antenna structure 100 is formed. Thus, by folding the sheet shaped support 2 along the respective fold-lines 3-7, an antenna device with antenna structures 100 is obtained in a simple manner, which can receive or emit spatially different electro-magnetic radiation, e.g., differently ~~polarised radiation,~~ polarized radiation.

[0028] However, the antenna structures may likewise be sensitive to radiation which differs in another spatial aspect. For example, the antenna structures may be sensitive to electromagnetic radiation from different directions and/or, for example, comprise so called horizontal antennas. Horizontal antennas are flat antennas sensitive to incident radiation with at least a radiation component orthogonal with respect to the plane in which the antennas lie whereas vertical antennas are sensitive to incident radiation with at least a radiation component parallel to the plane of the antennas. Thus, if a sheet-shaped support comprising two or more horizontal antenna structures is folded along fold-lines, such that two or more support planes each with one or more horizontal antenna structures are obtained, the antenna structures on the respective planes are sensitive to radiation from different directions.

[0029] The sheet shaped support 2 may be made of any foldable material suitable for the specific implementation. The antenna device 1 has an increased mechanical stiffness because of the fold-lines, which allows the support 2 to be made of a flexible material, which can be folded with a small amount of bending force. The flexible material may for example be a thin plastic foil, kapton, Mylar, Teflon, poly propylene, Poly ethylene or otherwise.

[0030] In the example of FIG. 1, the antenna structures 100 include a vertical antenna, but the antenna structures may include other types of antennas. In the

example, the antenna structure 100 comprises a patterned conductive surface layer 10 which extends over at least a part of the respective support planes 10-13. The conductive layer 101 is provided with a slot 106. The slot 106 has a tapered shape which narrows from an open, wide end 1061 at an edge of the support plane 10-13 towards a narrow end 1062 at a distance from the edge. At the narrow end, the slot 106 mounds in a circular space 1063.

[0031] The antenna structure 100 in the example of ~~FIG. 1,~~ FIG. 1 is of a type which is sometimes called a Vivaldi antenna. Such antennas are generally known in the art, for example from the European patent publication 0 349 069 A1 and United Kingdom Patent Number GB 1 601 441. The description of a Vivaldi antenna is hereby assumed to be incorporated herein by way of reference and for this reason the antenna structure will not be further described in detail herein. The Vivaldi antenna element provides an electrical ~~polarisation~~ polarization direction which is coplanar with the plane of the dielectric plate on which it is formed.

[0032] In the example of FIG. 1, a feed 102 extends across the tapered slot 106 at the narrow end 1062. The feed 102 is connected to an signal input of an amplifier 103, in this example a low noise amplifier, while a reference input of the amplifier 103 is connected to a ground 104. The amplifiers of the antenna structures 100 are further connected to a suitable control circuit and/or signal processing circuit 108 via contact lines 105 and connectors 107. A signal from the feed 102 can for example be transmitted to a signal processing circuit via the amplifier 103, the contact lines 105 and the connectors 107, while a suitable power supply can be provided to the amplifier 103 via the contact lines 105 and the connectors 107.

[0033] The connection between the antenna device and additional electronic circuitry may be implemented in any manner suitable for the specific implementation. For instance, a capacitive, inductive or other connection without physical contact can be used.

[0034] In the example of FIG. 1, the fold-lines 3-6 are parallel to each other and positioned at equal distances from each other. However, the fold-lines may be positioned in a non-parallel arrangement with respect to each other and/or a different spacing maybe present between the fold-lines. The sheet-shaped support 2 is folded along the fold-lines 3-6 into support planes which are perpendicular to each other. Accordingly, the folded sheet-shaped support 2 encloses a square shaped area. However, the sheet shaped support 2 may likewise be folded in a different manner. For example, the support planes 10-13 may be positioned at another angle with respect to each other, more or less support planes may be present. For instance, three support planes may be provided positioned at an angle of more or less 60 degrees with respect to each other.

[0035] In FIG. 1, the sheet-shaped support 2 is folded into a sleeve-like shape, with an open top and bottom. However, the sheet-shaped support 2 may be folded into another shape and/or with more or less open sides. The blank 40 shown in FIG. 2, for example, has, when folded into an antenna device, a closed bottom side which forms a base plane 15 of the antenna device.

[0036] FIG. 2 shows a top view of an example of an intermediate product, e.g., a blank 40, which can be folded to obtain an antenna device. The blank 40 comprises an elongated sheet-shaped support 2 provided with two or more, in this example four, flat antenna structures 100 arranged along the longitudinal direction of the sheet shaped support 2. The sheet-shaped support 2 is foldable along fold-lines 4-6 which extend across the sheet-shaped support 2 ~~from one of~~ and along the longitudinal edges ~~210,211~~ 209,210,211,212,213~~to the other longitudinal edge 211~~. The fold-lines divide the sheet-shaped support 2 into support planes 10-13, each of which has an antenna structure 100. An antenna device according to the invention can be manufactured from the blank 40 by folding the sheet-shaped support 2 along the fold-lines 4-6, such that the short edges 212,213 of the elongated support 2 are in contact with each other. By folding the blank 40 in this manner, a sleeve-shaped antenna device can be obtained.

[0037] In the example of FIG. 2 , the support 2 further has ~~at~~ along the longitudinal ~~edge~~ edges 209 and 210 an extension 220 adjacent to the support plane 11. The extension 220 is foldable along fold-line 7 with respect to the rest of the sheet-shaped support 2. The fold-line 7 extends in a direction transverse to the fold-lines 4-6 and parallel to the longitudinal edge 210. The extension 220 further has a fold-line 8 at a distance from and parallel to the fold-line 7. The fold-line 8 divides the extension into a plane 14 and a base plane 15. By suitable folding of the extension 220 along fold-lines 7 and 8, the base plane 15 of the extension 220 can be used as a bottom closure of the sleeve. Thus, a box-shaped antenna device can be obtained. For instance, the plane 14 can be folded along fold-line 7 such that the plane 14 lies parallel to and against the support plane 11. The base plane ~~18~~ 15 can then be folded along the fold-line 8 which divides the extension ~~20~~220, to extend transverse to the support plane 11 and form the base plane of an antenna device.

[0038] In the example of FIG. 2, the base plane 15 is covered at one side with a conducting layer, such as for example a metallic layer or otherwise. By ~~suitable~~ suitable folding the extension 220, the base plane 15 can be positioned with its conductive layer in contact with the conductive layer 101 on the support planes 10-13. In such case, the base plane 15 forms the bottom of the box-shaped folded support as well as an electrical base plane for the antennas device. For instance in the example of FIG. 2, the conductive layer 101 of the antenna structures 100 extends over a part of the width of the sheet-shaped support 2 only, as indicated with the dashed line ~~parallel~~ transverse to and located between the longitudinal edges 210,211. The fold-line 8 lies as far from the fold-line 7 as the edge of the conductive layer 101, indicated with the dashed line, lies from the longitudinal edge ~~210~~ 1061 of the sheet-shaped support 2. Thus, after folding, the fold-line 8 then lies against the edge of the conductive layer 101, indicated with the dashed line.

[0039] The invention is not limited to the arrangement of fold-lines and support planes shown in FIG. 2 and other arrangements are likewise possible. For instance ~~figs.~~ FIGs. 9-12 show, by way of example only, blanks 40 with alternative arrangements of the fold-lines and support planes.

[0040] In the example of FIG. 9, the support planes 10-13 are positioned in a line shaped arrangement and foldable along fold-lines 4-7 such that the lines 3,3' at the short ends of the blank ~~4~~ 40 are positioned in contact with each other. A base plane extension 15 is positioned at the lowerside of support plane 10 to form the base plane after folding along the fold-line 8. The example of FIG. 10 comprises two base-plane extensions 15a, 15b which extend over half the length of the base plane after folding. Such an extension arrangement ~~allows to manufacture the support plane~~ permits the support plane to be manufactured from a band of support plane material with negligible loss of material, because two support planes blanks 40,40' can be cut from the band, as is indicated in FIG. 10 ~~with~~ by the dashed lines.

[0041] In the example of ~~figs~~ FIGs. 11 and 12, the support planes 11,13 resp. 10-13 are connected to each other via the base plane which can be formed by folding along fold-lines 80,81 resp. 80-83. Thereby, the respective support planes 13,11 resp. 10-13 adjacent to the base plane 15 are in contact with the base plane, and when the base plane has to be an electrical base plane, electrical contact between the base plane 15 and the adjacent support planes is ensured. Furthermore, the examples of FIG. 11 and 12 can be modified easily to obtain an antenna device with a frustrated pyramid-like shape by providing the support planes 11,13 resp, 10-13 with a trapezoid shape.

[0042] The antenna structure 100 and the sheet-shaped support 2 may be implemented in any manner suitable for the specific implementation. As shown in FIG. 3, the sheet-shaped support 2 and/or the antenna structures 100 may for instance be a multilayer structure. A multilayer structure can for instance be used to integrate two or more functions of the antenna device. In the example of FIG. 3, the tapered notch antenna, the feed and the connection of the antenna device are integrated.

[0043] In FIG. 3, the sheet-shaped support 2 comprises a first electrically ~~isolating~~ insulating layer 20, which may for instance be made out of a plastic material, such

as polyethylene, polypropylene, cartboard, kapton or otherwise. The first electrically ~~isolating~~ insulating layer 20 is provided at a backside with a first electrically conductive layer 22.

[0044] The first electrically conductive layer 22, for example, may be provided in a relatively simple manner, by adhering a conductive foil, such as ~~aluminium~~ aluminum foil, to the backside of the electrically ~~isolating~~ insulating layer 20. Techniques for ~~fixating aluminium~~ fixing aluminum foil onto a plastic layer, such as polypropylene or polyethylene, are generally known, for example in the field of packaging food products and are for the sake of brevity not described in further detail. However, the electrically conductive layer 22 may be obtained in any other manner suitable for the specific implementation.

[0045] A second electrically conducting layer 23 is present at a front side, opposite to the backside, of the first electrically ~~isolating~~ insulating layer 20. The second electrically conducting layer 23 can, for instance, be strip-shaped and be formed into the feed 102 of an antenna structure 100 suitable for the example of FIG. 1.

[0046] The strip-shaped electrically conducting layer 23 lies between the first electrically ~~isolating~~ insulating layer 20 and a second electrically ~~isolating~~ insulating layer 21. A third electrically conducting layer 24 lies on top of the second electrically ~~isolating~~ insulating layer 21, which is shaped into a ground connection of an amplifier 103 or other electronic circuitry present in the antenna structure 100. The ground connection in the third electrically conducting layer 24 is connectable to the first electrically conducting layer 22 by means of a passage 25 in which an electrically conducting pin can be positioned which then connects the first and third electrically conducting layers 22,24 electrically. The third electrically conducting layer is further shaped into connecting lines 105 for transmitting signals from or to the antenna. Thus, the connecting lines 105 are integrated in the flat design of the antenna structures 100. Thereby, the antenna structures 100 can be connected to further circuitry in a simple manner and there is no necessity to connect cables directly to the amplifier 103 of the feed 102.

[0047] FIG. 4 shows an example of an antenna array 30 which includes two or more examples of antenna devices 1', 1" according to the invention. As indicated in FIG. 4 by way of example with reference numbers 200,201, the antenna array comprises one or more step ~~shaped-folded-~~shaped-folded supports provided with antenna structures. The step-shaped folded supports 200,201 are folded into a number of antenna devices 1',1" according to the invention. The antenna devices 1',1" are provided with antenna structures 100 each have an electro-magnetic ~~polarisation~~ polarization direction which is coplanar with the plane of the support plane on which the antenna structure 100 is formed. The antenna array 30 therefore comprises sets of antenna device 1' resp. 1"_with different orthogonal orientations, as indicated with the arrows A and B, and the antenna array 30 is a dual ~~polarised-~~polarized antenna array which can be used to receive or emit electro-magnetic radiation with different ~~polarisations~~polarizations.

[0048] Additionally, each set of antenna devices 1'_resp. 1" comprises arrangements of antenna device 1' resp. 1" in the direction of arrow A and arrangements in the direction of arrow B. Accordingly, each set forms a matrix-shaped arrangement with a certain ~~polarisation-~~polarization and the antenna array 30 shown in FIG. 4 comprises two, intermingled matrix-shaped arrangements each of which has a different ~~polarisation~~polarization.

[0049] In FIG. 4, the antenna devices 1'1," are positioned in a two-dimensional matrix shaped arrangement. It should be noted that in general any number of antenna elements may be used and the invention is not limited to the shown number of antenna elements. Furthermore, the antenna elements may likewise be positioned in an arrangement different from the line-shaped arrangement in FIG. 4 such as, depending on the specific implementation, a line-shaped arrangement, a random distribution, a three dimensional arrangement or otherwise.

[0050] In the example of FIG. 4, the support 200 is folded along more than one fold-line. The support 200 is repeatedly folded along a fold-line in a first direction

and in a following fold-line in a second direction ~~opposite~~ perpendicular to the first direction, such that a stair-shaped support is obtained, as is for instance shown in FIG. 6. A number of supports folded in a similar fashion is positioned parallel to the support 200. However, the invention is not limited to the specific manner in which the support 200 is folded. The supports may likewise be folded in another manner. FIG. 5, for example, shows a support 200 which is folded along a first pair of fold-lines in a first direction and a following pair of fold-lines in a second direction, such that the support is locally U-shaped. FIG. 7 shows a support which is first folded along a first set of three equally spaced fold-lines in a first direction and then again along a second set of three equally spaced fold-lines at that same direction, to obtain two sleeve shaped antenna devices 1a and 1b.

[0051] In the antenna array 30 shown in FIG. 4, the supports are attached near the fold-lines to each other by means of clamps 202. ~~A fixation~~ Fixation by means of clamps is low-cost and ~~non-complex~~simple. However, the supports may likewise be attached in another manner. For instance, ~~of~~ different sheets may be glued to each other in the support planes or otherwise.

[0052] The antenna array system shown in FIG. 4 may be implemented as a ~~phased array~~ phased-array antenna. For instance, ~~by connecting~~ the different sets of antenna devices 1' resp. 1" may be connected to suitable beam forming and control circuitry. ~~Phased array~~ Phased-array antennas are generally known, for instance, from the American patent publication US 6,232,919 and the European patent publication EP 805 509.

[0053] In FIG. 13, the operation of such an antenna system is illustrated. The antenna system shown comprises, by way of example, four antenna units 401-404 which are arranged next to each other in one line. The antenna units 401-404 are each connected with an amplifier device 511-514, respectively. The amplifier devices 511-514 are each connected with a respective time- or phase-shifting circuit 521-524. The time- or phase-shifting circuits 521-524 are connected with each other through combining circuits 611-613 in an electronic circuit 600. The antenna

system shown in FIG. 4 could be designed as a ~~phased-array~~ phased-array antenna system, for instance, by adding time- or phase-shifting circuits, for instance, via different lengths of the contact lines 105, implementing the amplifier devices 103 in the signal processing circuit 500 and connecting the contact lines 105 to a suitable electronic circuit.

[0054] The antenna units 401-404 can receive electromagnetic radiation which reaches the antenna at an angle which is within the viewing range. In FIG. ~~7~~ 13 a bundle of electromagnetic radiation is shown which is built up from four parallel rays s1-s4. In the example shown, the ray s1 incident on the antenna unit 401 has a phase phi1. The ray s2 incident on the antenna unit 402, however, must cover an additional distance Δl_1, which is equal to the distance between the antenna units multiplied by the cosine of the angle α which the rays make with the plane X in which the antenna units are situated. As a result, the ray s2 has a ~~phase shift~~phase-shift relative to the ray s1 at the moment when the antenna is reached. The phases of the rays s3 and s4 differ similarly. In the antenna system, this ~~phase shift~~phase-shift can be compensated by setting the phase- or time-shift of the phase- or time-shifting circuits ~~521-524,~~ 521-524 such that the mutual differences thereof correspond to the phase differences in the incoming rays. In this way, because the phase- or time-shift depends on the angle of the incoming radiation, the direction in which the antenna system receives can be adjusted.

[0055] By designing an antenna system according to the invention as a ~~phased-array~~ phased-array antenna, an inexpensive antenna unit is obtained which can be simply directed electronically at a source by setting the time- or phase-shifting circuits. Moreover, several sources can be received ~~simultaneously,~~ simultaneously by connecting each of the antenna units with several time- or phase-shifting circuits and setting a separate shift for each source to be received. Further, with a ~~phased array~~ phased-array antenna, a rotation of the antenna system relative to the source can be automatically compensated electronically. For instance, satellite receivers mounted on ships and trucks, and in general on moving carriers, are subject to such

rotation, so that the known receiver, at least the antennas thereof, must be held in position mechanically. With a ~~phased-array~~ phased-array antenna system as proposed, this mechanical compensation can be replaced with an electronic ~~compensation,~~ compensation which is cheaper and more wear-resistant than the former.

[0056] It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design alternatives without departing from the scope of the appended claims. For instance, a line of weakness may be provided to the sheet shaped support to facilitate ~~the~~ folding. Also, the fold-lines may, for example, be provided at other positions of the support than shown and/or the support planes may be oriented differently with respect to each other. Furthermore, the antenna device may, for example, comprise more or ~~less~~ fewer support planes than shown herein. Also, the antenna device may be positioned in recesses of a cover which shields ~~shielding~~ the antenna device from environmental influences, such as water, temperature or otherwise. Such a cover may, for example, be made of a foam material and, for instance, be provided with one or more slots corresponding to the shape of the support. Other variations and modifications are likewise possible and features from different embodiments may be combined.

[0057] ~~In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim.~~ The word 'comprising' does not exclude the presence of other elements or steps than those listed in a claim. Unless explicitly specified otherwise, the word 'a' is used as including one, two, three, or more of the specified elements. The mere fact that certain measures are recited in mutually different claims does not indicate that a combination of these measures cannot be used to advantage.

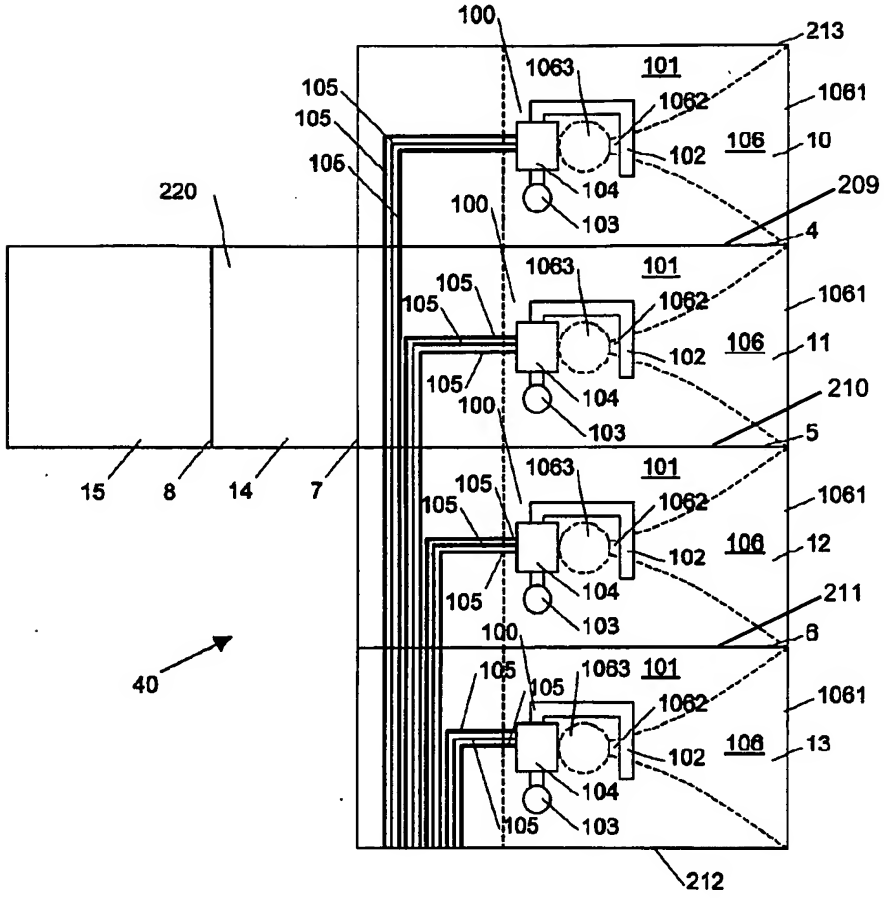

Fig. 2

Fig. 5

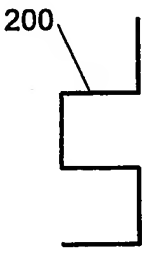

Fig. 6

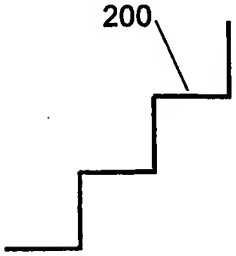

Fig. 7

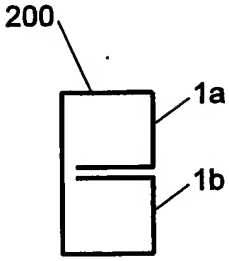

Fig. 8

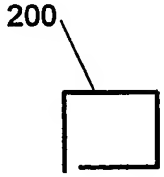

Fig. 9

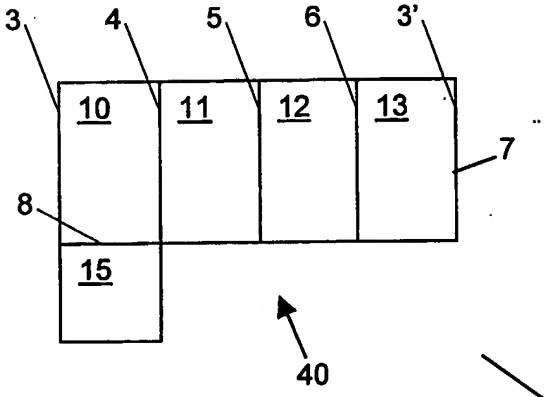

Fig 10

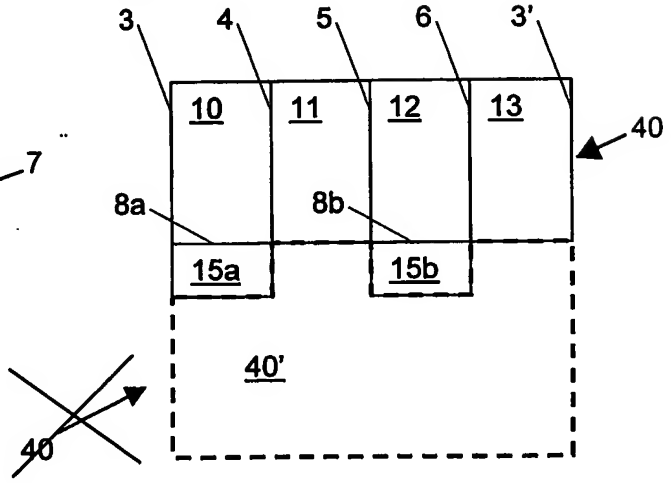

Fig. 11

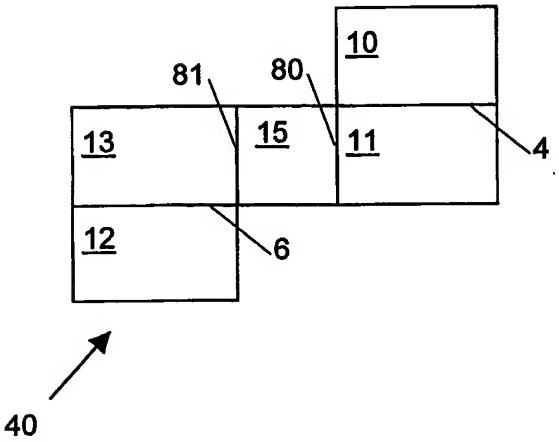

Fig. 12